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PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT
INSPECTION OF CONCRETE

Report No. 90-184-K

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Abstract

The structural concrete in the interior and exterior of the Pressure Relief Duct was inspected during the Pickering NGS 1990 outage. The inspection consisted of visual observation, nondestructive testing, concrete coring and half-cell potential measurements. The concrete throughout the structure was found to be in generally good condition. Spalled concrete was present around the hinge joints in the interior of the Pickering NGS "B" side of the duct. These areas were repaired during the outage.

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To Dr. C.F. Lee
Manager
Civil Engineering and Architecture Department

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT
INSPECTION OF CONCRETE

1.0 INTRODUCTION

An inspection of the structural concrete in the interior and exterior of the Pressure Relief Duct (PRD) was carried out during the station outage in May 1990. The inspection followed the program prepared by the Central Production Services Division (PNGS CPS-N-20000-0004) and included visual observation, nondestructive testing, concrete coring and half-cell potential measurements.

This report summarizes the results of the inspection including any deficiencies noted and the actions taken to repair them.

2.0 INSPECTION RESULTS

The transverse joints in the PRD are numbered in the Pickering NGS "A" side from 28 to 0, and in the Pickering NGS "B" side from 33 to 76, from west to east. The joints at Units 1 to 4 and Units 5 to 6 are numbered from 29 to 32 and 77 to 80, respectively. Figures A and B show the configuration of the duct (Figure 1).

Horizontal construction joints extend along the north and south sides of the duct approximately 500 mm above the top of the floor slab.

2.1 Interior

2.1.1 Interior Surfaces of Duct

The interior of the duct was inspected visually along its entire length to a height of 2 m above the floor. At selected locations, the portion of the wall above 2 m and the ceiling were inspected from man-lifts. The location of typical cracks observed in the walls and ceiling of the duct are given in Table 1. The inspection also included the drilling of concrete cores from the floor to evaluate the quality of the concrete and to expose reinforcing steel for examination.

A detailed visual inspection of the Pickering NGS "A" side of the duct was carried out in 1987 and reported in Research Division Report 87-58-H. Selected cracks reported in 1987 were reinspected during the outage to determine whether or not changes had occurred over the three year period. Based on the results of the

inspection, given in Table 1, it appears that the crack widths have increased and that additional cracks have developed. The most significant crack, in the south wall of the duct between Joints 15 to 16, had a width of 0.90 mm (Figure 2). In general, the concrete appeared in good condition.

The Pickering NGS "B" side of the duct had not been previously inspected. The concrete appeared in good condition with only a few vertical cracks having a maximum width of 0.40 mm. On this side of the duct, the cracks appeared to be fewer and narrower than on the "A" side.

Three concrete cores were drilled from the floor west of Joint 12 and three from the floor east of Joint 50. The concrete in the cores appeared in good condition based on a visual examination. Laboratory testing of specimens prepared from the cores could not be carried out at the time of the inspection because of the radioactive nature of the concrete. One core at each of the two locations was drilled to expose reinforcing steel. The exposed steel was in good condition and showed no evidence of corrosion. Half-cell potential measurements carried out on the floor slab and reported in Appendix A, concluded that there was a greater than 90% probability that no corrosion of the reinforcing steel was taking place in the vicinity of Joint 12 when the measurements were taken. Similar results were obtained at Joint 50 except for one location where the corrosion activity of the reinforcing steel was uncertain.

2.1.2 Transverse Joints

The transverse joints in the PRD consist of three kinds: construction, hinge, and contraction. The concrete around selected joints was inspected visually and evaluated nondestructively with ultrasonic pulse velocity and impact hammer readings. The results of the inspection are given in Table 2.

The concrete was found to be spalled around some of the hinge joints on the Pickering NGS "B" side of the duct. These areas were generally associated with the embedded steel of the joints (Figure 3). The cause of the spalled concrete was not determined and may have been present since construction. Joint 50 had been examined in detail before the outage because of an accumulation of water in the floor of the duct at this joint. The results of this inspection are summarized in Research Division Report S90-20-K. This report indicated that the leakage of water into the duct appeared to occur at spalled concrete (Figure 4).

The joints were repaired by removing all spalled concrete and sealing the concrete steel interface with caulking (Figure 5) to prevent leakage. The spalled concrete extended to a maximum of about 75 mm into the wall. Based on consultation with the Civil Engineering and Architecture Department, the spalled concrete was felt not to be structurally significant.

Other than a few hairline cracks and the spalled areas noted above, no other deterioration was observed at the transverse joints inspected.

The ultrasonic pulse velocity readings were generally lower than anticipated, although most represented good quality concrete (reading > 3700 m/s). The low readings may reflect fine hairline cracks which were not readily discernible. The impact hammer readings indicated the concrete was of good quality.

2.1.3 Horizontal Joints

The horizontal construction joints, extending along the north and south walls of the duct about 500 mm from the floor, were inspected between Joints 12 and 16 and between Joints 50 and 55. The inspection consisted of evaluating the integrity of the joints ultrasonically. Readings were taken across the joints and the pulse velocities compared to values obtained in the concrete adjacent to the joint. The results are given in Table 3.

Based on the test results, it appeared that the joints on the Pickering NGS "B" side of the duct were in better condition than those on the "A" side. On the Pickering NGS "A" side, low pulse velocities were obtained across

the joints in some locations, indicating that the joints were not as well bonded as they were in NGS 'B' side. It may also indicate that hairline cracks were present in the concrete. The readings taken across the joints on the Pickering "B" side were similar to the values obtained in the concrete adjacent to the joint, indicating that the joints were probably well bonded.

The ultrasonic pulse velocity readings taken in the concrete adjacent to the joints were frequently low (< 3700 m/s) indicating that hairline cracks probably exist in the concrete.

2.1.4 Embedded Parts

The concrete around the air locks and embedded parts in the floor of the PRD was visually inspected. The concrete around the air locks appeared in good condition with only hairline cracks. Hairline cracks were also present in the concrete around the embedded parts in the floor.

During the outage, the door to the equipment air lock (EP 51143) in the floor fell shut. Because of the mass of the door, concern was expressed regarding the condition of the concrete around the air lock. Visual inspection and nondestructive testing did not identify any damage to the concrete that may have resulted from this incident. The hairline cracks extending from the hatch were estimated ultrasonically to be 100 mm deep but many were filled with material which could influence the readings. Impact hammer readings around the hatchway indicated that the concrete was of good quality.

2.2 Exterior

2.2.1 Exterior Surfaces of Duct

The inspection of the exterior of the PRD concentrated on the roof and the underside of the duct as described in the sections below. A man-lift was used to access the underside of the duct.

An inspection of the exterior concrete of the Pickering NGS "A" side of the duct was carried out in 1988 and reported in Research Division Report 88-295-K. Because of this previous inspection, the Pickering NGS "A" side of the duct was only given a cursory examination.

2.2.2 Roof Slab

The roof of the PRD was visually inspected and the condition of the concrete evaluated nondestructively at selected locations. The observations and test results are summarized in Table 4.

The concrete appeared to be in good condition, and had changed little since the 1988 inspection. The most significant deterioration noted was spalled concrete along the edges of the duct (Figures 6 and 7). The spalled areas were generally associated with the embedded bolts of the beam support pedestals. These areas did not appear to be structurally significant.

An inspection of Joint 50, from the roof during the initial pressure test, identified leakage at the south end of the joint on the roof under a beam support pedestal (Figure 8).

A void in the concrete was identified on the underside of the link between the Unit 7 Reactor Building and the PRD. The void was an area of localized honeycombed concrete and has been present since construction. The depth of this void was not determined since it was considered to be a localized defect.

Nondestructive tests conducted on the roof slab of the Pickering NGS "B" side of the duct confirmed that the concrete was of good quality.

2.2.3 Transverse Joints and Supports

The transverse joints at the supports were inspected from a man-lift. The results of this inspection are given in Table 5.

The concrete appeared in good condition. Minor spalling and hairline cracks (<0.05 mm wide) were noted around some of the embedded steel pads and in the underside of the duct (Figure 9). Both the spalling and cracking did not appear to be significant.

Evidence of leakage, in the form of efflorescence, was noted at the base of some joints (Figure 10).

Exposed reinforcing steel was observed at some locations on the underside of the duct. This steel generally exhibited some surface rust (Figure 11) and appeared to be exposed because of insufficient concrete cover. No spalling of the concrete associated with corrosion of the reinforcing was observed. Debonded concrete was observed at previously repaired areas (Figure 12).

Cracking was noted across the northwest and southwest corners of the support for Joint 36 (Figure 13), that will probably result in the spalling of the concrete.

3.0 DEFICIENCIES AND REMEDIAL ACTION

(a) In the interior of the duct, spalled concrete was identified at localized areas around some of the hinge joints on the Pickering NGS "B" side of the duct. The spalled areas extended to a depth of 75 mm. At these joints, all spalled concrete was removed, and the contact between the concrete and the embedded steel of the joint caulked.

(b) On the exterior of the duct, a number of areas of spalled concrete were identified. These spalled areas do not appear to be structurally significant and no remedial action was recommended at the present time.

4.0 SUMMARY AND CONCLUSIONS

1. The concrete investigated in the PRD was found to be in generally good condition although low ultrasonic pulse velocity readings were obtained adjacent to the horizontal construction joints in the walls of the duct. This indicates that hairline cracks may be present in the concrete at these locations.

2. Cracks in the Pickering NGS "A" side of the duct appear to have increased in width since an inspection conducted in 1987. The structural significance of this change should be evaluated.

3. On the Pickering NGS "B" side of the duct, spalled areas of concrete were identified around the hinge joints. The spalled concrete was removed and the contact between the concrete and the embedded steel sealed with caulking.

4. Spalled concrete was identified on the exterior of the duct at various locations. These areas were generally associated with the beam support pedestals and previous repairs.

5. The presence of hairline cracks, honeycombed sections of concrete and exposed reinforcing steel observed during this inspection do not at present appear significant. However, the significance of leakage at joints should be evaluated.

5.0 INSPECTION TEAM

The inspection of the concrete in the Pressure Relief Duct during the Pickering NGS 1990 outage was carried out by H. Caratin, E.J. McColm, J. Vitanyi, C.J. Hernes, M.F. Everitt, and J. Aloisio with assistance from J.J. Deans, of the Concrete Technology Section, Civil Research Department. The half-cell potential readings were carried out by A.C. Headon and B.I. Guest of the Metallurgical Research Department.

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TABLE 1

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE

Location	Remarks
Pickering NGS "A"	
Between Joints 5 and 6 North Wall	Vertical crack - 0.50 mm wide in 1990 - 0.25 mm wide in 1987
East of Joint 10 South Wall	Spalled concrete adjacent to embedded steel plate
Between Joints 10 and 11 North Wall	Vertical crack present through epoxy repair
Between Joints 12 and 13 North Wall	Vertical crack present through epoxy repair
Between Joints 13 and 14 South Wall	Vertical crack not previously reported - width 0.13 mm
Between Joints 14 to 15 North Wall	Vertical crack not previously reported - width <0.05 mm
Between Joints 15 and 16 North Wall	Vertical crack - 0.40 to 0.50 mm wide in 1990 - 0.25 to 0.40 mm wide in 1987
Between Joints 15 and 16 South Wall	Vertical crack - 0.90 mm wide in 1990 (4 m west of Joint 15) - 0.70 mm wide in 1987 (Figure 2) Vertical crack - 0.50 mm wide in 1990 (3 m west of Joint 15) - 0.25 mm wide in 1987
Between Joints 16 and 17 South Wall	Vertical crack not previously reported - width 0.50 mm
Between Joints 17 and 18 North Wall	Vertical crack not previously reported - width 0.40 mm
Between Joints 21 and 22 South Wall	Vertical crack not previously reported - width 0.25 mm
Between Joints 22 and 23 North Wall	Vertical crack not previously reported - width 0.13 mm
Between Joints 24 and 25 South Wall	Two vertical cracks not previously reported - widths 0.25 mm and 0.50 mm
Between Joints 27 and 28 South Wall	Vertical crack not previously reported - width 0.40 mm

TABLE 1 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE

Location	Remarks
Pickering NGS "B"	
Between Joints 39 and 40 South Wall	Vertical crack - width 0.25 mm
Between Joints 63 and 64 South Wall	Vertical crack - width 0.40 mm
Between Joints 65 and 66 North Wall	Vertical crack - width 0.40 mm
Between Joints 65 and 66 South Wall	Vertical crack - width 0.25 mm
Between Joints 69 and 70 South Wall	Two vertical cracks - widths 0.40 mm
Between Joints 73 and 74 South Wall	Two vertical cracks - widths 0.25 mm
Between Joints 75 and 76 South Wall	Vertical crack - width 0.40 mm

TABLE 2

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

Location	Remarks and Nondestructive Test Results
Pickering NGS "A"	
Joint 2 (Hinge Joint)	- Average Rebound Number (relative strength) + - South wall, west of joint, 2 m above floor 52.3 (54 MPa) - North wall, west of joint, 2 m above floor 50.9 (52 MPa) - Ultrasonic Pulse Velocity Readings (m/s) North Wall West Side Near Floor / South Wall West Side Near Floor A 4500 4300 B 4400 4400 C 4300 4200 D 4300 4400 E 4400 4300 F 4400 4600
Joint 3 (Contraction Joint)	- Average Rebound Number (relative strength) + - South wall, east of joint, 2 m above floor 51.6 (53 MPa) - North wall, west of joint, 2 m above floor 47.7 (46 MPa) - Ultrasonic Pulse Velocity Readings (m/s) North Wall East Side Near Floor / South Wall East Side Near Floor A 4000 3600 B 4000 4000 C 4000 3800 D 4400 3600 E 4200 4000 F 4100 4000

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

<table>
<tr><th>Location</th><th>Remarks and Nondestructive Test Results</th></tr>
<tr><td>Joint 5
(Contraction Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, west of joint, 2 m above floor 51.6 (53 MPa)
- North wall, west of joint, 2 m above floor 46.3 (44 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
West Side
Near Floor</th><th>South Wall
East Side
Near Floor</th></tr>
<tr><td>A</td><td>3700</td><td>4400</td></tr>
<tr><td>B</td><td>4200</td><td>4000</td></tr>
<tr><td>C</td><td>4400</td><td>4100</td></tr>
<tr><td>D</td><td>4200</td><td>3900</td></tr>
<tr><td>E</td><td>4500</td><td>4200</td></tr>
<tr><td>F</td><td>4500</td><td>4200</td></tr>
</table>
</td></tr>
<tr><td>Joint 10
(Contraction Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, east of joint, 2 m above floor 44.8 (41 MPa)
- North wall, west of joint, 2 m above floor 52.8 (54 MPa)
- South wall, east of joint, near ceiling 48.4 (48 MPa)
- North wall, west of joint, near ceiling 46.9 (45 MPa)
- Ceiling 53.2 (50 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
West Side
Near Floor</th><th>South Wall
East Side
Near Floor</th><th>North Wall
West Side
Near Ceiling</th><th>South Wall
East Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4500</td><td>3800</td><td>4600</td><td>4100</td></tr>
<tr><td>B</td><td>4400</td><td>4100</td><td>4100</td><td>4100</td></tr>
<tr><td>C</td><td>4500</td><td>4000</td><td>4200</td><td>4100</td></tr>
<tr><td>D</td><td>4300</td><td>4400</td><td>4600</td><td>4200</td></tr>
<tr><td>E</td><td>4400</td><td>4400</td><td>3900</td><td>4200</td></tr>
<tr><td>F</td><td>4200</td><td>-</td><td>-</td><td>-</td></tr>
</table>
</td></tr>
</table>

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

Location	Remarks and Nondestructive Test Results
Joint 11 (Contraction Joint)	- Average Rebound Number (relative strength)+ - South wall, west of joint, 2 m above floor — 51.1 (52 MPa) - North wall, east of joint, 2 m above floor — 43.8 (40 MPa) - South wall, west of joint, near ceiling — 46.0 (43 MPa) - North wall, east of joint, near ceiling — 47.4 (46 MPa) - Ceiling — 53.1 (50 MPa) - Ultrasonic Pulse Velocity Readings (m/s)

	North Wall East Side Near Floor	South Wall West Side Near Floor	North Wall East Side Near Ceiling	South Wall West Side Near Ceiling
A	4600	4600	3800	3700
B	4700	4400	3800	3800
C	4500	4400	3800	3800
D	4800	4200	3600	3900
E	4800	4100	3800	4300
F	4200	-	-	-

Location	Remarks and Nondestructive Test Results
Joint 12 (Hinge Joint)	- Average Rebound Number (relative strength)+ - South wall, west of joint, 2 m above floor — 48.3 (48 MPa) - North wall, east of joint, 2 m above floor — 56.3 (>59 MPa) - South wall, west of joint, near ceiling — 50.8 (52 MPa) - North wall, east of joint, near ceiling — 46.3 (44 MPa) - Ceiling — 55.0 (53 MPa) - Ultrasonic Pulse Velocity Readings (m/s)

	North Wall East Side Near Floor	South Wall West Side Near Floor	North Wall East Side Near Ceiling	South Wall West Side Near Ceiling
A	4300	4400	4200	4400
B	4100	4400	4400	4100
C	4300	4200	4200	3800
D	4200	4100	4200	4400
E	4100	4000	4100	4400
F	4200	4300	-	-

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

Location	Remarks and Nondestructive Test Results
Joint 13 (Contraction Joint)	- Average Rebound Number (relative strength)+ - South wall, west of joint, 2 m above floor — 52.3 (54 MPa) - North wall, east of joint, 2 m above floor — 53.7 (57 MPa) - South wall, west of joint, near ceiling — 51.0 (52 MPa) - North wall, east of joint, near ceiling — 52.4 (54 MPa) - Ceiling — 50.2 (46 MPa) - Ultrasonic Pulse Velocity Readings (m/s)

	North Wall East Side Near Floor	South Wall West Side Near Floor	North Wall East Side Near Ceiling	South Wall West Side Near Ceiling
A	4000	4100	4100	4100
B	4000	4400	3700	4100
C	3600	4000	4200	4100
D	3600	3800	4200	4100
E	4000	3700	4100	4000
F	3800	3700	-	-

Location	Remarks and Nondestructive Test Results
Joint 14 (Contraction Joint)	- Average Rebound Number (relative strength)+ - South wall, east of joint, 2 m above floor — 52.4 (54 MPa) - North wall, west of joint, 2 m above floor — 48.6 (48 MPa) - South wall, east of joint, near ceiling — 50.9 (52 MPa) - North wall, west of joint, near ceiling — 48.2 (48 MPa) - Ceiling — 54.8 (53 MPa) - Ultrasonic Pulse Velocity Readings (m/s)

	North Wall East Side Near Floor	South Wall West Side Near Floor	North Wall East Side Near Ceiling	South Wall West Side Near Ceiling
A	4500	4500	4400	4000
B	4800	4200	4000	4200
C	4100	4100	4400	4100
D	3800	4100	4400	4000
E	4500	4400	4200	4400
F	3800	4200	-	-

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

<table>
<tr><th>Location</th><th>Remarks and Nondestructive Test Results</th></tr>
<tr><td>Joint 15
(Contraction Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, west of joint, 2 m above floor — 50.6 (51 MPa)
- North wall, east of joint, 2 m above floor — 49.4 (50 MPa)
- South wall, west of joint, near ceiling — 46.8 (45 MPa)
- North wall, east of joint, near ceiling — 48.1 (48 MPa)
- Ceiling — 54.7 (53 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
East Side
Near Floor</th><th>South Wall
West Side
Near Floor</th><th>North Wall
East Side
Near Ceiling</th><th>South Wall
West Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4800</td><td>5000</td><td>4300</td><td>3800</td></tr>
<tr><td>B</td><td>4200</td><td>4900</td><td>3900</td><td>3700</td></tr>
<tr><td>C</td><td>4600</td><td>4500</td><td>4200</td><td>4100</td></tr>
<tr><td>D</td><td>4700</td><td>4600</td><td>4200</td><td>4200</td></tr>
<tr><td>E</td><td>4400</td><td>4300</td><td>4100</td><td>4200</td></tr>
<tr><td>F</td><td>4100</td><td>4300</td><td>-</td><td>-</td></tr>
</table>
</td></tr>
<tr><td>Joint 16
(Hinge Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, east of joint, 2 m above floor — 52.0 (54 MPa)
- North wall, west of joint, 2 m above floor — 49.6 (50 MPa)
- South wall, east of joint, near ceiling — 51.0 (52 MPa)
- North wall, west of joint, near ceiling — 57.0 (>59 MPa)
- Ceiling — 53.2 (51 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
West Side
Near Floor</th><th>South Wall
East Side
Near Floor</th><th>North Wall
West Side
Near Ceiling</th><th>South Wall
East Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4100</td><td>4200</td><td>4200</td><td>4400</td></tr>
<tr><td>B</td><td>4100</td><td>4500</td><td>4100</td><td>4200</td></tr>
<tr><td>C</td><td>3800</td><td>4500</td><td>4100</td><td>4100</td></tr>
<tr><td>D</td><td>4000</td><td>4400</td><td>3800</td><td>3900</td></tr>
<tr><td>E</td><td>4300</td><td>4100</td><td>4200</td><td>4200</td></tr>
<tr><td>F</td><td>3800</td><td>4200</td><td>-</td><td>-</td></tr>
</table>

- No spalled concrete was identified
</td></tr>
</table>

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

<table>
<tr><th>Location</th><th>Remarks and Nondestructive Test Results</th></tr>
<tr><td>Joint 18
(Contraction Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, west of joint, 2 m above floor 41.3 (36 MPa)
- North wall, east of joint, 2 m above floor 52.8 (54 MPa)
- South wall, west of joint, near ceiling 48.5 (48 MPa)
- North wall, east of joint, near ceiling 47.0 (45 MPa)
- Ceiling 54.7 (53 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
East Side
Near Floor</th><th>South Wall*
West Side
Near Floor</th><th>North Wall
East Side
Near Ceiling</th><th>South Wall
West Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4500</td><td>4000</td><td>4400</td><td>4100</td></tr>
<tr><td>B</td><td>4300</td><td>3900</td><td>4200</td><td>4200</td></tr>
<tr><td>C</td><td>4300</td><td>3800</td><td>4200</td><td>4100</td></tr>
<tr><td>D</td><td>4100</td><td>3700</td><td>4400</td><td>4100</td></tr>
<tr><td>E</td><td>4200</td><td>3600</td><td>4200</td><td>4000</td></tr>
<tr><td>F</td><td>4100</td><td>3500</td><td>-</td><td>-</td></tr>
</table>
*Surface of concrete was rough
</td></tr>
<tr><td>Joint 20
(Hinge Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, west of joint, 2 m above floor 48.6 (48 MPa)
- North wall, east of joint, 2 m above floor 46.3 (45 MPa)
- South wall, west of joint, near ceiling 46.7 (45 MPa)
- North wall, east of joint, near ceiling 42.4 (38 MPa)
- Ceiling 48.3 (42 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
East Side
Near Floor</th><th>South Wall
West Side
Near Floor</th><th>North Wall
East Side
Near Ceiling</th><th>South Wall
West Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4200</td><td>4300</td><td>4100</td><td>4300</td></tr>
<tr><td>B</td><td>4100</td><td>4000</td><td>4100</td><td>4200</td></tr>
<tr><td>C</td><td>3800</td><td>3800</td><td>4000</td><td>4000</td></tr>
<tr><td>D</td><td>4300</td><td>4200</td><td>4100</td><td>4300</td></tr>
<tr><td>E</td><td>4000</td><td>4000</td><td>4300</td><td>4000</td></tr>
<tr><td>F</td><td>3900</td><td>3900</td><td>-</td><td>-</td></tr>
</table>
- No spalled concrete was identified
</td></tr>
</table>

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

<table>
<tr><th>Location</th><th>Remarks and Nondestructive Test Results</th></tr>
<tr><td>Joint 21
(Contraction Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, west of joint, 2 m above floor 47.8 (47 MPa)
- North wall, east of joint, 2 m above floor 43.9 (40 MPa)
- South wall, west of joint, near ceiling 46.4 (45 MPa)
- North wall, east of joint, near ceiling 43.6 (40 MPa)
- Ceiling 52.9 (50 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall*
East Side
Near Floor</th><th>South Wall*
West Side
Near Floor</th><th>North Wall
East Side
Near Ceiling</th><th>South Wall
West Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4600</td><td>3800</td><td>3500</td><td>4000</td></tr>
<tr><td>B</td><td>3800</td><td>3300</td><td>3800</td><td>4000</td></tr>
<tr><td>C</td><td>4200</td><td>3200</td><td>3900</td><td>3900</td></tr>
<tr><td>D</td><td>4100</td><td>4000</td><td>4000</td><td>3700</td></tr>
<tr><td>E</td><td>3900</td><td>4000</td><td>4000</td><td>3700</td></tr>
<tr><td>F</td><td>4000</td><td>3600</td><td>-</td><td>-</td></tr>
</table>
*Surface of concrete was rough
</td></tr>
<tr><td>Joint 26
(Hinge Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, east of joint, 2 m above floor 51.1 (52 MPa)
- North wall, west of joint, 2 m above floor 44.1 (41 MPa)
- South wall, east of joint, near ceiling 48.1 (42 MPa)
- North wall, west of joint, near ceiling 47.3 (45 MPa)
- Ceiling 54.5 (53 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
West Side
Near Floor</th><th>South Wall
East Side
Near Floor</th><th>North Wall
West Side
Near Ceiling</th><th>South Wall
East Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4200</td><td>4200</td><td>-</td><td>4000</td></tr>
<tr><td>B</td><td>4100</td><td>4200</td><td>4100</td><td>4300</td></tr>
<tr><td>C</td><td>4000</td><td>4300</td><td>4000</td><td>3800</td></tr>
<tr><td>D</td><td>4200</td><td>4400</td><td>4000</td><td>3800</td></tr>
<tr><td>E</td><td>4300</td><td>4200</td><td>4300</td><td>3500</td></tr>
<tr><td>F</td><td>-</td><td>4300</td><td>-</td><td>-</td></tr>
</table>
- No spalled concrete was identified
</td></tr>
</table>

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

Location	Remarks and Nondestructive Test Results
West End of Duct	- Average Rebound Number (relative strength)+ - 2 m above floor 50.0 (50 MPa) - Ultrasonic Pulse Velocity Readings (m/s) Near Floor A 4000 B 3800 C 3800 D 4000 E 4100 F 4000 - No spalled concrete was identified along the walls to a height of 2 m. Remainder of walls and ceiling not accessible

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

Location	Remarks and Nondestructive Test Results
Pickering NGS "B"	
Joint 33 (Construction Joint)	- Average Rebound Number (relative strength)+ - South wall, west of joint, 2 m above floor: 47.7 (47 MPa) - North wall, east of joint, 2 m above floor: 52.4 (54 MPa) - South wall, west of joint, near ceiling: not accessible - North wall, east of joint, near ceiling: 47.0 (45 MPa) - Ceiling: 52.6 (54 MPa) - Ultrasonic Pulse Velocity Readings (m/s)

	North Wall East Side Near Floor	South Wall West Side Near Floor	North Wall East Side Near Ceiling	South Wall West Side Near Ceiling
A	4400	4100	4400	not accessible
B	4400	4100	4800	-
C	4400	-	4400	-
D	4100	4100	4400	-
E	4100	4200	4700	-
F	4400	4100	-	-

Joint 34 (Hinge Joint)	- No spalled concrete was identified

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

<table>
<tr><th>Location</th><th>Remarks and Nondestructive Test Results</th></tr>
<tr><td>Joint 36
(Construction Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, east of joint, 2 m above floor — 46.8 (45 MPa)
- North wall, west of joint, 2 m above floor — 50.8 (52 MPa)
- South wall, east of joint, near ceiling — 41.6 (37 MPa)
- North wall, west of joint, near ceiling — 42.6 (38 MPa)
- Ceiling — 54.6 (53 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
West Side
Near Floor</th><th>South Wall
East Side
Near Floor</th><th>North Wall
West Side
Near Ceiling</th><th>South Wall
East Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4400</td><td>4300</td><td>4800</td><td>4100</td></tr>
<tr><td>B</td><td>4100</td><td>4400</td><td>4200</td><td>4100</td></tr>
<tr><td>C</td><td>4200</td><td>4100</td><td>4200</td><td>4100</td></tr>
<tr><td>D</td><td>4300</td><td>4000</td><td>4400</td><td>4100</td></tr>
<tr><td>E</td><td>3800</td><td>4000</td><td>4000</td><td>4200</td></tr>
<tr><td>F</td><td>3300</td><td>4100</td><td>-</td><td>-</td></tr>
</table>
</td></tr>
<tr><td>Joint 38
(Hinge Joint)</td><td>- Spalled concrete was identified at one location in the south wall.</td></tr>
<tr><td>Joint 42
(Hinge Joint)</td><td>- Spalled concrete was identified at two locations in the south wall and one location in the ceiling.</td></tr>
<tr><td>Joint 46
(Hinge Joint)</td><td>- Three areas of spalled concrete were identified in the north wall. Two of these areas had been previously repaired. In the south wall and ceiling one area of spalled concrete was identified at each location.</td></tr>
</table>

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

<table>
<tr><th>Location</th><th>Remarks and Nondestructive Test Results</th></tr>
<tr><td>Joint 47
(Construction Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, east of joint, 2 m above floor 50.0 (50 MPa)
- North wall, west of joint, 2 m above floor 51.0 (52 MPa)
- South wall, west of joint, near ceiling 47.9 (47 MPa)
- North wall, east of joint, near ceiling 48.8 (48 MPa)
- Ceiling 52.0 (54 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
East Side
Near Floor</th><th>South Wall
West Side
Near Floor</th><th>North Wall
East Side
Near Ceiling</th><th>South Wall
West Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4300</td><td>4200</td><td>4300</td><td>4100</td></tr>
<tr><td>B</td><td>4200</td><td>4100</td><td>4500</td><td>4100</td></tr>
<tr><td>C</td><td>4200</td><td>3700</td><td>4200</td><td>4100</td></tr>
<tr><td>D</td><td>4200</td><td>4400</td><td>4000</td><td>4200</td></tr>
<tr><td>E</td><td>4200</td><td>4400</td><td>4300</td><td>4100</td></tr>
<tr><td>F</td><td>4100</td><td>4000</td><td>-</td><td>-</td></tr>
</table>
</td></tr>
<tr><td>Joint 50
(Hinge Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, east of joint, 2 m above floor 47.3 (46 MPa)
- North wall, west of joint, 2 m above floor 50.7 (52 MPa)
- South wall, east of joint, near ceiling 45.7 (43 MPa)
- North wall, west of joint, near ceiling 48.8 (48 MPa)
- Ceiling 54.7 (53 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
West Side
Near Floor</th><th>South Wall
East Side
Near Floor</th><th>North Wall
West Side
Near Ceiling</th><th>South Wall
East Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4300</td><td>4500</td><td>4200</td><td>4100</td></tr>
<tr><td>B</td><td>4000</td><td>4200</td><td>4300</td><td>4100</td></tr>
<tr><td>C</td><td>4100</td><td>-</td><td>4200</td><td>4400</td></tr>
<tr><td>D</td><td>3800</td><td>4200</td><td>4000</td><td>4300</td></tr>
<tr><td>E</td><td>4000</td><td>4000</td><td>4200</td><td>4200</td></tr>
<tr><td>F</td><td>4100</td><td>4200</td><td>-</td><td>-</td></tr>
</table>
- Areas of spalled concrete were identified in both walls
</td></tr>
</table>

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

Location	Remarks and Nondestructive Test Results
Joint 53 (Contraction Joint)	- Average Rebound Number (relative strength)+ - South wall, west of joint, 2 m above floor: 49.0 (48 MPa) - North wall, east of joint, 2 m above floor: 46.9 (45 MPa) - South wall, west of joint, near ceiling: 45.2 (43 MPa) - North wall, east of joint, near ceiling: 39.5 (33 MPa) - Ceiling: 50.2 (45 MPa) - Ultrasonic Pulse Velocity Readings (m/s) A: 4400 (North Wall East Side Near Floor); 4200 (South Wall West Side Near Floor); 4100 (North Wall East Side Near Ceiling); not accessible (South Wall West Side Near Ceiling) B: 4100; 4100; 4100; - C: 4100; 4100; 4100; - D: 4000; 4100; 4100; - E: 4000; -; 4100; - F: 4200; 3800; -; -
Joint 56 (Hinge Joint)	- Average Rebound Number(relative strength)+ - South wall, west of joint, 2 m above floor: 50.9 (52 MPa) - North wall, east of joint, 2 m above floor: 52.7 (54 MPa) - South wall, west of joint, near ceiling: 45.8 (43 MPa) - North wall, east of joint, near ceiling: 46.8 (45 MPa) - Ceiling: 53.1 (51 MPa) - Ultrasonic Pulse Velocity Readings (m/s) A: 4300 (North Wall East Side Near Floor); 4300 (South Wall West Side Near Floor); 4100 (North Wall East Side Near Ceiling); 4200 (South Wall West Side Near Ceiling) B: 4200; 4100; 4100; 4100 C: 4300; 3800; 4300; 4200 D: 4500; 3600; 4300; 4100 E: 4000; -; 4200; 4100 F: 4000; 3800; -; - - Spalled concrete was identified at four locations in the ceiling
Joint 60 (Hinge Joint)	- No spalled concrete was identified.

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

Location	Remarks and Nondestructive Test Results
Joint 61 (Construction Joint)	- No spalled concrete was identified.
Joint 64 (Hinge Joint)	- Average Rebound Number (relative strength)+ - South wall, east of joint, 2 m above floor — 48.9 (48 MPa) - North wall, west of joint, 2 m above floor — 51.9 (53 MPa) - South wall, east of joint, near ceiling — 47.2 (45 MPa) - North wall, west of joint, near ceiling — 49.1 (48 MPa) - Ceiling — 52.7 (50 MPa) - Ultrasonic Pulse Velocity Readings (m/s) A: North Wall West Side Near Floor 4100; South Wall East Side Near Floor 4100; North Wall West Side Near Floor 3800; South Wall East Side Near Floor 4100 B: 4100; 4100; 3900; 4100 C: 4100; -; 3800; 4100 D: 4200; 3800; 3900; 4100 E: 4100; -; 3900; 4200 F: 3800; 4100; -; - - One area of spalled concrete was identified in the south wall
Joint 68 (Hinge Joint)	- One area of spalled concrete was identified in the north wall.

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

<table>
<tr><th>Location</th><th>Remarks and Nondestructive Test Results</th></tr>
<tr><td>Joint 71
(Contraction Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, east of joint, 2 m above floor — 45.9 (43 MPa)
- North wall, west of joint, 2 m above floor — 50.0 (50 MPa)
- South wall, east of joint, near ceiling — 43.8 (40 MPa)
- North wall, west of joint, near ceiling — not accessible
- Ceiling — 48.8 (43 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
West Side
Near Floor</th><th>South Wall
East Side
Near Floor</th><th>North Wall
West Side
Near Ceiling</th><th>South Wall
East Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4100</td><td>3800</td><td>not accessible</td><td>3900</td></tr>
<tr><td>B</td><td>3900</td><td>3600</td><td>-</td><td>3800</td></tr>
<tr><td>C</td><td>4000</td><td>3600</td><td>-</td><td>4000</td></tr>
<tr><td>D</td><td>3900</td><td>3800</td><td>-</td><td>3900</td></tr>
<tr><td>E</td><td>4000</td><td>-</td><td>-</td><td>3800</td></tr>
<tr><td>F</td><td>3800</td><td>-</td><td>-</td><td>-</td></tr>
</table>
</td></tr>
<tr><td>Joint 74
(Hinge Joint)</td><td>
- Average Rebound Number (relative strength)+
- South wall, east of joint, 2 m above floor — 44.9 (42 MPa)
- North wall, west of joint, 2 m above floor — 49.4 (48 MPa)
- South wall, east of joint, near ceiling — not accessible
- North wall, west of joint, near ceiling — 45.4 (43 MPa)
- Ceiling — 51.5 (48 MPa)

- Ultrasonic Pulse Velocity Readings (m/s)

<table>
<tr><th></th><th>North Wall
West Side
Near Floor</th><th>South Wall
East Side
Near Floor</th><th>North Wall
West Side
Near Ceiling</th><th>South Wall
East Side
Near Ceiling</th></tr>
<tr><td>A</td><td>4000</td><td>3800</td><td>4000</td><td>not accessible</td></tr>
<tr><td>B</td><td>4100</td><td>3400</td><td>3800</td><td></td></tr>
<tr><td>C</td><td>4100</td><td>3600</td><td>3800</td><td></td></tr>
<tr><td>D</td><td>4000</td><td>3700</td><td>4000</td><td></td></tr>
<tr><td>E</td><td>4000</td><td>3700</td><td>3900</td><td></td></tr>
<tr><td>F</td><td>3800</td><td>3700</td><td>-</td><td></td></tr>
</table>
- No spalled concrete was identified in the north wall or north side of the ceiling. The south wall and south side of the ceiling were not accessible for inspection
</td></tr>
</table>

(+)The Rebound Numbers are the average of 10 readings.

TABLE 2 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS

Location	Remarks and Nondestructive Test Results
Joint 76 (Construction Joint)	- Spalled concrete was identified in the south wall and in the ceiling.
East End of Duct	- Average Rebound Number (relative strength)+ - 2 m above floor (rough surface) 36.6 (29 MPa) - 2 m below floor 38.2 (31 MPa) - Ceiling 47.0 (40 MPa) - Ultrasonic Pulse Velocity Readings (m/s) Near Floor / Near Ceiling A 3200 / 3600 B 3600 / 3700 C 3600 / 3300 D 3500 / 3700 E 3300 / - F 3700 / 3700

(+)The Rebound Numbers are the average of 10 readings.

TABLE 3

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT HORIZONTAL CONSTRUCTION JOINTS

Location	Ultrasonic Pulse Velocity Readings (m/s)			
Pickering NGS "A"				
Horizontal Joint Between Joints 12 and 13		Path	North Wall	South Wall
	A	across joint	3600	2200
	B	across joint	2100	2200
	C	across joint	2700	1600
	D	across joint	2900	2100
	E	across joint	2000	2300
	A'	concrete adjacent to joint	4100	3600
	E'	concrete adjacent to joint	3800	3600
Horizontal Joint Between Joints 13 and 14		Path	North Wall	South Wall
	A	across joint	3800	2500
	B	across joint	3400	3300
	C	across joint	2600	2900
	D	across joint	2700	1800
	E	across joint	2300	2400
	B'	concrete adjacent to joint	4100	4300
	D'	concrete adjacent to joint	4100	4100
Horizontal Joint Between Joints 14 and 15		Path	North Wall	South Wall
	A	across joint	2500	2600
	B	across joint	2700	2300
	C	across joint	3100	2300
	D	across joint	2700	2400
	E	across joint	2700	2400
	D'	concrete adjacent to joint	3600	3600
	E'	concrete adjacent to joint	3600	3500

TABLE 3 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT HORIZONTAL CONSTRUCTION JOINTS

Location	Ultrasonic Pulse Velocity Readings (m/s)			
Horizontal Joint Between Joints 15 and 16		Path	North Wall	South Wall
	A	across joint	3600	2200
	B	across joint	2400	1900
	C	across joint	2500	2300
	D	across joint	2700	2600
	E	across joint	3800	4000
	C'	concrete adjacent to joint	4300	4000
	B'	concrete adjacent to joint	4500	2900
Pickering NGS "B"				
Horizontal Joint Between Joints 50 and 51		Path	North Wall	South Wall
	A	across joint	3300	2700
	B	across joint	2900	2800
	C	across joint	4000	3200
	D	across joint	3300	3500
	E	across joint	2700	3600
	C'	concrete adjacent to concrete	3700	-
	D'	concrete adjacent to concrete	3700	3600
Horizontal Joint Between Joints 51 and 52		Path	North Wall	South Wall
	A	across joint	4100	3200
	B	across joint	3900	3500
	C	across joint	4200	3300
	D	across joint	4200	3700
	E	across joint	4400	4100
	B'	concrete adjacent to joint	4200	3700
	E'	concrete adjacent to joint	4600	4400

TABLE 3 (cont'd)

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - INTERIOR
INSPECTION OF CONCRETE AT HORIZONTAL CONSTRUCTION JOINTS

Location	Ultrasonic Pulse Velocity Readings (m/s)			
Horizontal Joint Between Joints 52 and 53		Path	North Wall	South Wall
	A	across joint	4400	4000
	B	across joint	4200	3800
	C	across joint	3800	3600
	D	across joint	3600	3800
	E	across joint	3900	3600
	A'	concrete adjacent to joint	4000	3900
	D'	concrete adjacent to joint	3700	3700
Horizontal Joint Between Joints 53 and 54		Path	North Wall	South Wall
	A	across joint	3300	3800
	B	across joint	3100	3900
	C	across joint	4400	4000
	D	across joint	4000	3200
	E	across joint	3900	4000
	C'	concrete adjacent to joint	3900	4100
	D'	concrete adjacent to joint	4100	3600
Horizontal Joint Between Joints 54 and 55		Path	North Wall	South Wall
	A	across joint	3800	3000
	B	across joint	3800	3100
	C	across joint	3800	3300
	D	across joint	3600	2600
	E	across joint	3500	3200
	B'	concrete adjacent to joint	3300	4400
	D'	concrete adjacent to joint	3800	4400
Horizontal Joint Between Joints 55 and 56		Path	North Wall	South Wall
	A	across joint	4400	4000
	B	across joint	4200	3800
	C	across joint	3800	3600
	D	across joint	3600	3800
	E	across joint	3900	3600
	C'	concrete adjacent to joint	4000	3900
	D'	concrete adjacent to joint	3700	3700

TABLE 4

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT - EXTERIOR
INSPECTION OF CONCRETE FROM ROOF OF DUCT

Location	Remarks
Pickering NGS "A"	
South side of duct at Joint 2	- entire south side of joint inspected - concrete in good condition
South side of duct at Joint 3	- spalled concrete at beam support pedestal
North side of duct east of Joint 10	- small area of spalled concrete at beam support pedestal
North side of duct at Joint 16	- entire north side of joint inspected - concrete in good condition
North side of duct at joint with Unit 3 (Joint 31)	- area previously repaired has spalled (Figure 6)
Pickering NGS "B"	
South side of duct west of Joint 35	- efflorescence noted along a crack on the side of the duct - spall affecting an area 1000 by 300 mm along edge of duct
North side of duct west of Joint 36	- spalled concrete at beam support pedestal
Centre of duct east of Joint 40	- average rebound number 43.7 (relative strength 34 MPa)
South side of duct east of Joint 40	- spall in top of duct adjacent to beam support pedestal
South side of duct east of Joint 41	- crack on side of duct adjacent to beam support pedestal (Figure 7)
Centre of duct east of Joint 50	- average rebound number 40.2 (relative strength 29 MPa)
Centre of duct at Joint 58	- steel covering of neoprene seal badly corroded making seal ineffective
Centre of duct west of Joint 60	- average rebound number 45.9 (relative strength 38 MPa)
Centre of duct west of Joint 70	- average rebound number 47.0 (relative strength 32 MPa)
Centre of duct at Joint 73	- joint sealant debonding at edges of joint

TABLE 5

PICKERING NGS - 1990 OUTAGE
PRESSURE RELIEF DUCT - EXTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS AND SUPPORTS

Location	Remarks	
Pickering NGS "A"		
Joint 0	North side	- exposed reinforcing steel on underside of duct and at support beam (Figure 11). Cracks in support (width 0.13 mm)
	South side	- concrete in good condition, hairline crack in support
Joint 2	North side	- concrete in good condition, west side not accessible
	South side	- concrete in good condition, west side not accessible
Joint 5	North side	- concrete in good condition
	South side	- not accessible
Joint 8	North side	- area previously repaired east of joint was sound - exposed reinforcing steel on underside of duct
	South side	- area previously repaired was sound
Joint 12	North side	- concrete in good condition - a few hairline cracks in supports
	South side	- concrete in good condition - a few hairline cracks in supports
Joint 14	North side	- not accessible
	South side	- area of honeycombed concrete in support - hairline cracks in support
Joint 16	North side	- not accessible
	South side	- spalling of east side of support - pattern cracking on underside of duct west of joint (Figure 9) - efflorescence at base of joint (Figure 10)
Joint 18	North side	- not accessible
	South side	- exposed reinforcing steel east of joint - repairs present in support
Joint 20	North side	- not accessible
	South side	- joint inspected from a distance of 3 m - concrete in good condition - evidence of leaking (efflorescence) at base of joint - evidence of debonding of a repair made along the west side of the support beam under the duct (Figure 12)

TABLE 5 (cont'd)

PICKERING NGS - 1990 OUTAGE
PRESSURE RELIEF DUCT - EXTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS AND SUPPORTS

Location		Remarks
Joint 23	North side	- concrete in good condition - hairline cracks present
	South side	- concrete in good condition - hairline cracks present
Joint 26	North side	- not accessible - spalling of support
	South side	- evident of leakage (efflorescence) at base of joint - spalling of support
Joint 28	West end of duct	- one small area of honeycombed concrete was present at the end of the duct
Pickering NGS "B"		
Joint 34	North side	- minor spalling of concrete along horizontal construction joint east of Joint 34
	South side	- minor spalling of concrete along horizontal construction joint east of Joint 34
Joint 36	North side	- potential spall of northwest corner of support - 1 mm wide crack at corner
	South side	- potential spall of southwest corner of support (Figure 13)
Joint 38	North side	- concrete in good condition
	South side	- concrete in good condition
Joint 40	North side	- concrete in good condition
	South side	- concrete in good condition - spalled concrete around steel embedded plate
Joint 44	North side	- concrete in good condition
	South side	- concrete in good condition - corrosion of cover over neoprene joint seal
Joints 46 and 48		- not accessible

TABLE 5 (cont'd)

PICKERING NGS - 1990 OUTAGE
PRESSURE RELIEF DUCT - EXTERIOR
INSPECTION OF CONCRETE AT TRANSVERSE JOINTS AND SUPPORTS

Location		Remarks
Joint 50	North side	- concrete in good condition
	South side	- evidence of leakage (efflorescence) near base of joint - concrete in good condition
Joint 58	North side	- small spall east of joint - concrete in good condition
	South side	- concrete in good condition
Joint 60	North side	- concrete in good condition
	South side	- hairline crack <0.05 mm wide
Joint 62	North side	- exposed steel on east and west side of joint
	South side	- exposed steel on east and west side of joint
Joint 64	North side	- concrete in good condition
	South side	- on west side, minor spall with hairline crack
Joint 66	North side	- concrete in good condition - east side of joint not accessible
	South side	- concrete in good condition
Joint 68	North side	- concrete in good condition - west side of joint not accessible
	South side	- concrete in good condition - west side of joint not accessible
Joint 71	North side	- sealant was debonded at edges - repaired spalls along the support beam were sound
	South side	- concrete in good condition
Joint 74	North side	- not accessible
	South side	- crack (width <0.13 mm) at southwest corner of duct

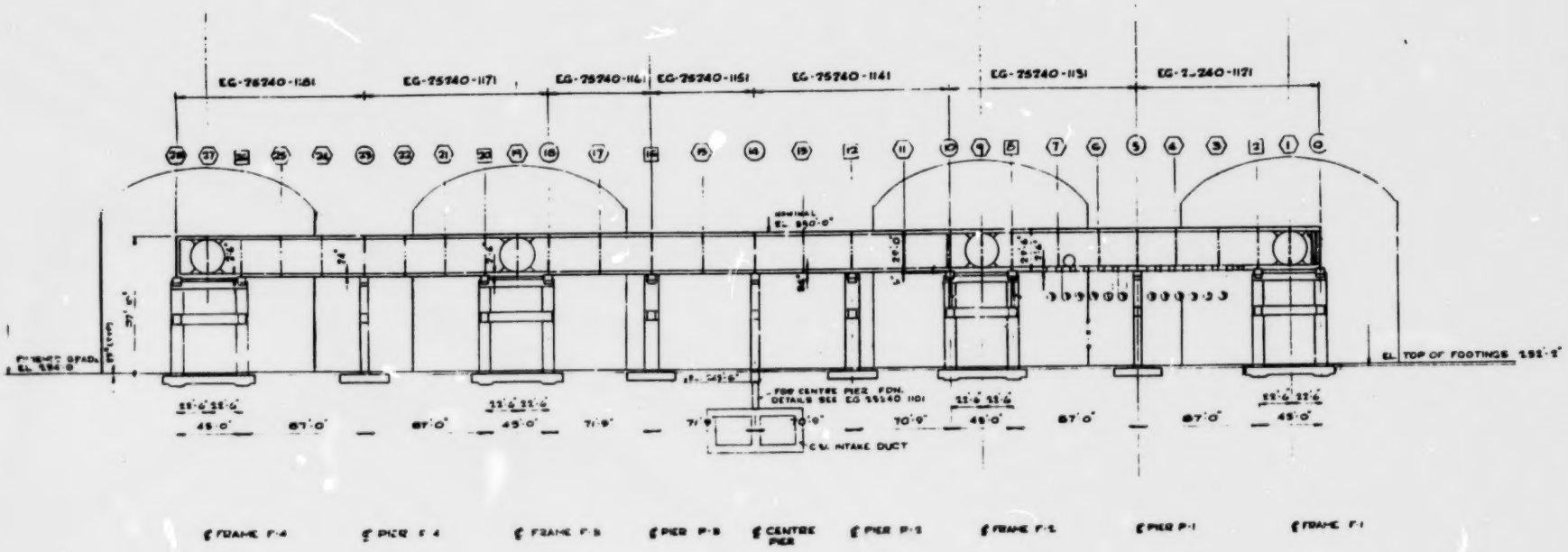

Figure A

Pickering NGS "A" 1990 Outage
Pressure Relief Duct
Section View

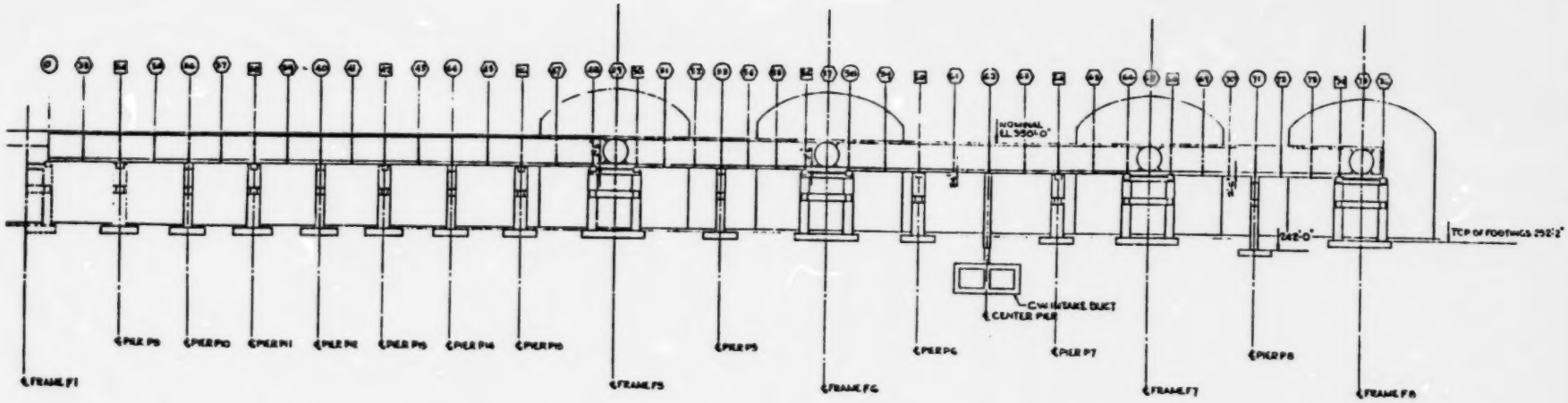

Figure B

Pickering NGS "B" 1990 Outage
Pressure Relief Duct
Section View

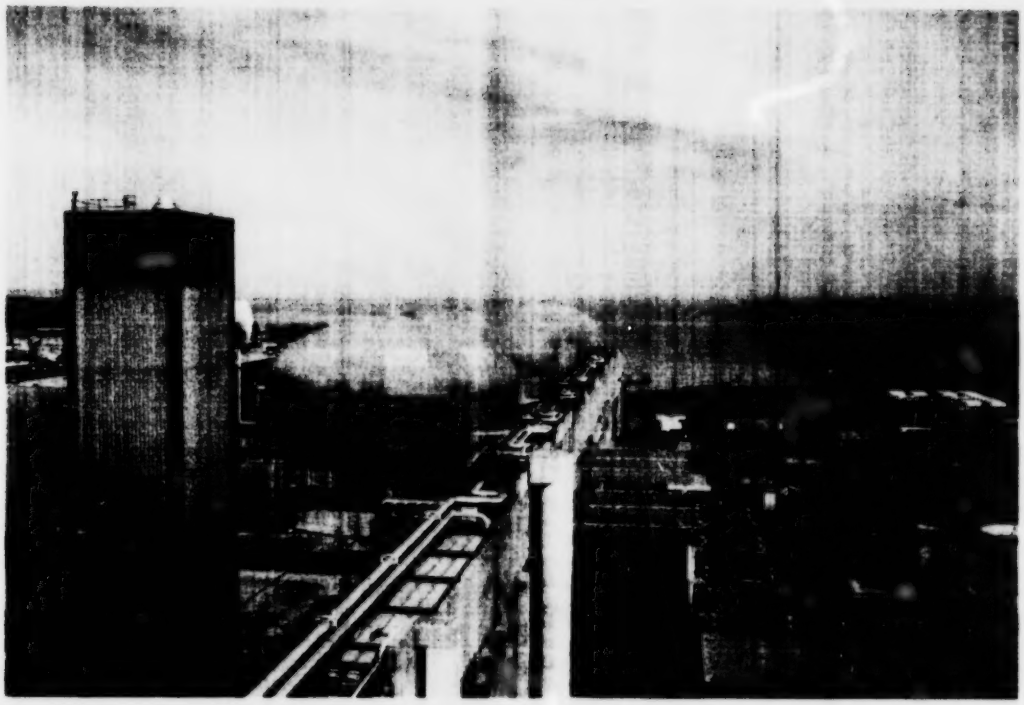

Figure 1 View of the Pickering NGS "B" portion of the Pressure Relief Duct.

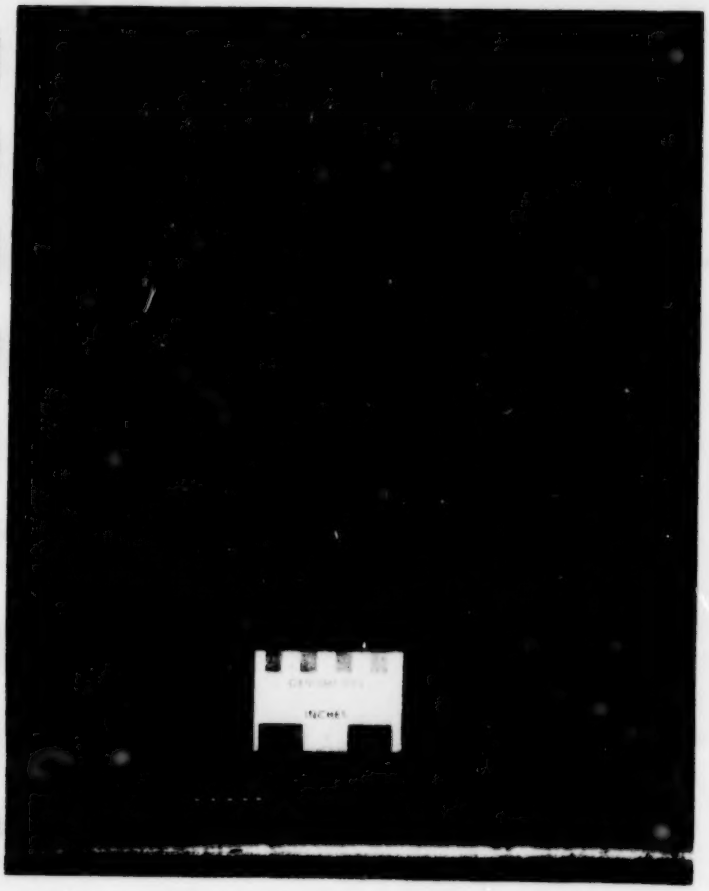

Figure 2 Vertical crack in the south wall of the duct between Joints 15 and 16. In 1987, this crack was reported to have a width of 0.70 mm. During the 1990 inspection the crack width was measured as 0.90 mm.

Figure 3 ← Concrete removed from a spalled area adjacent to a typical hinge joint in the Pickering NGS "B" side of the duct. Note the location of a embedded steel anchor in the center of the spalled area.

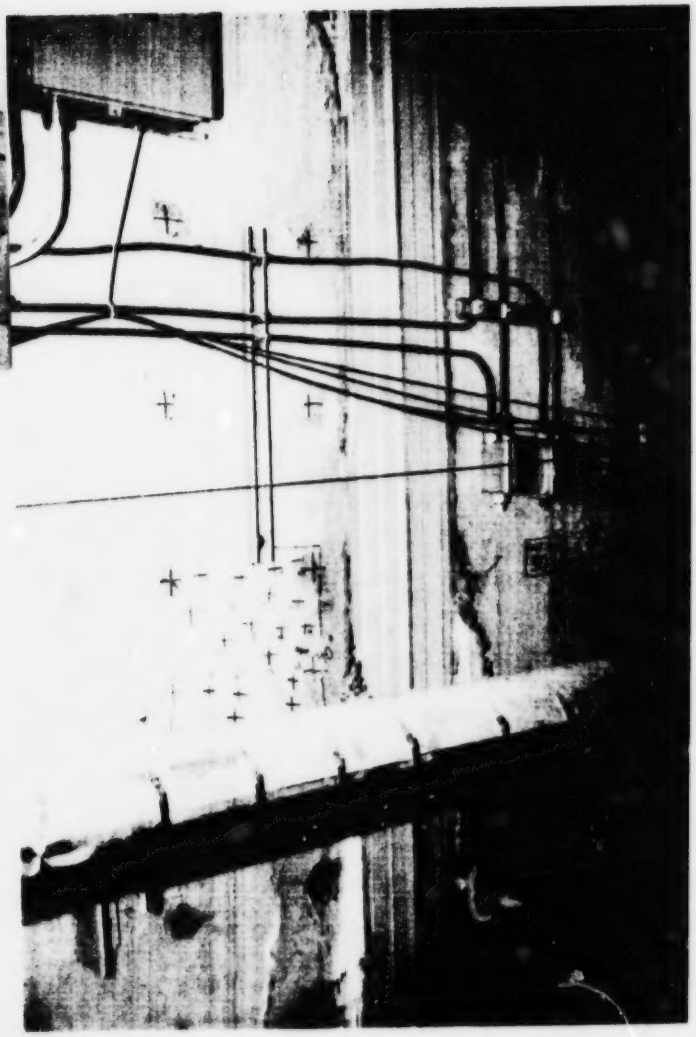

Figure 4 - Shown is the south side of Joint 50 where evidence of leakage (efflorescence) was observed. →

Figure 5 ← Caulking applied to a typical area of spalled concrete adjacent to a hinge joint. This area was similar to that shown in Figure 3.

Figure 6 - Spall at the link between the Pressure Relief Duct and Unit 3 Reactor Building (Joint 31). →

Figure 7 ← Spalling at the south side of the duct east of Joint 41.

Figure 8 - Location of leakage identified during the outage pressure test. The leakage was identified under the beam support pedestal at the south end of Joint 50. →

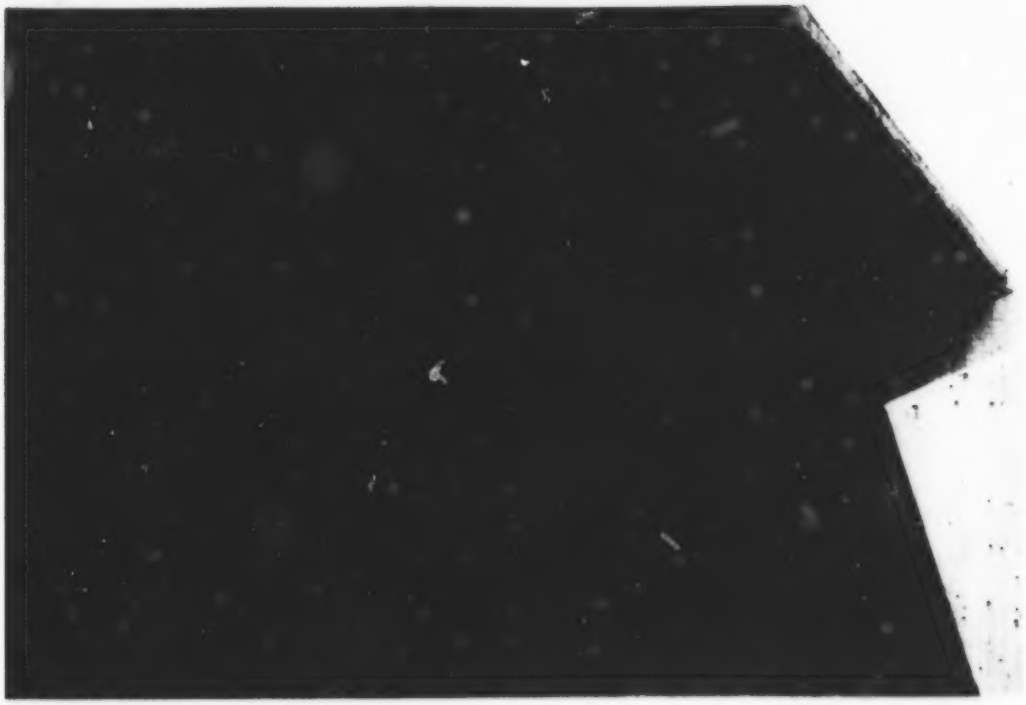

Figure 9 Hairline map cracking on the underside of the duct west of Joint 16.

Figure 10 Evidence of leakage (efflorescence) at the base of the south side of Joint 16.

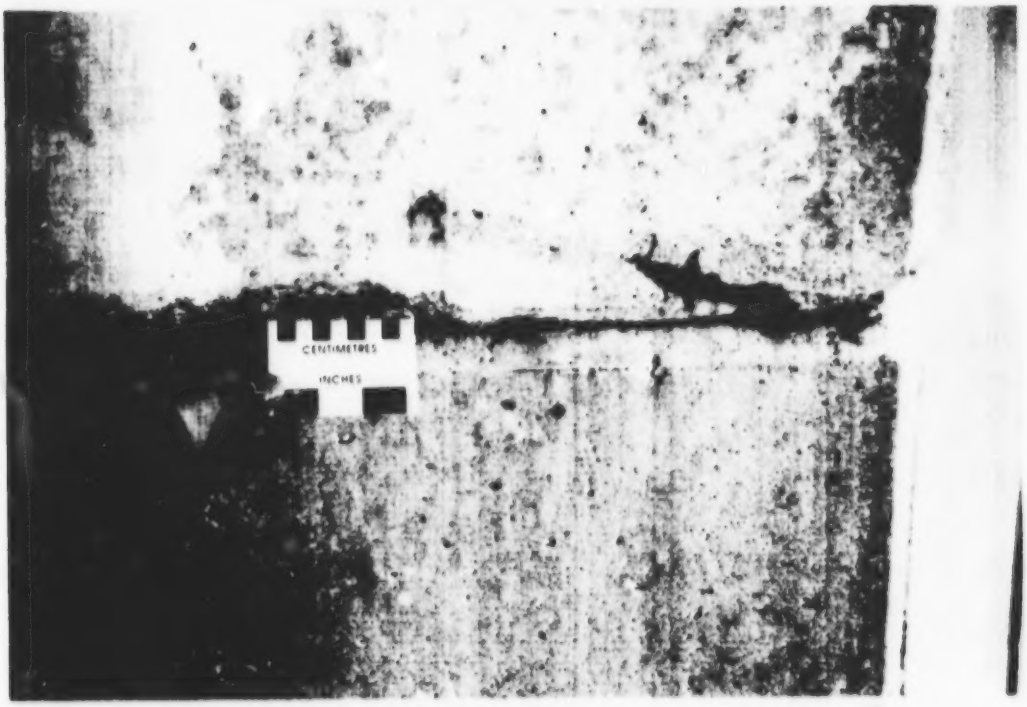

Figure 11 Exposed reinforcing steel in north support column of Joint 0.

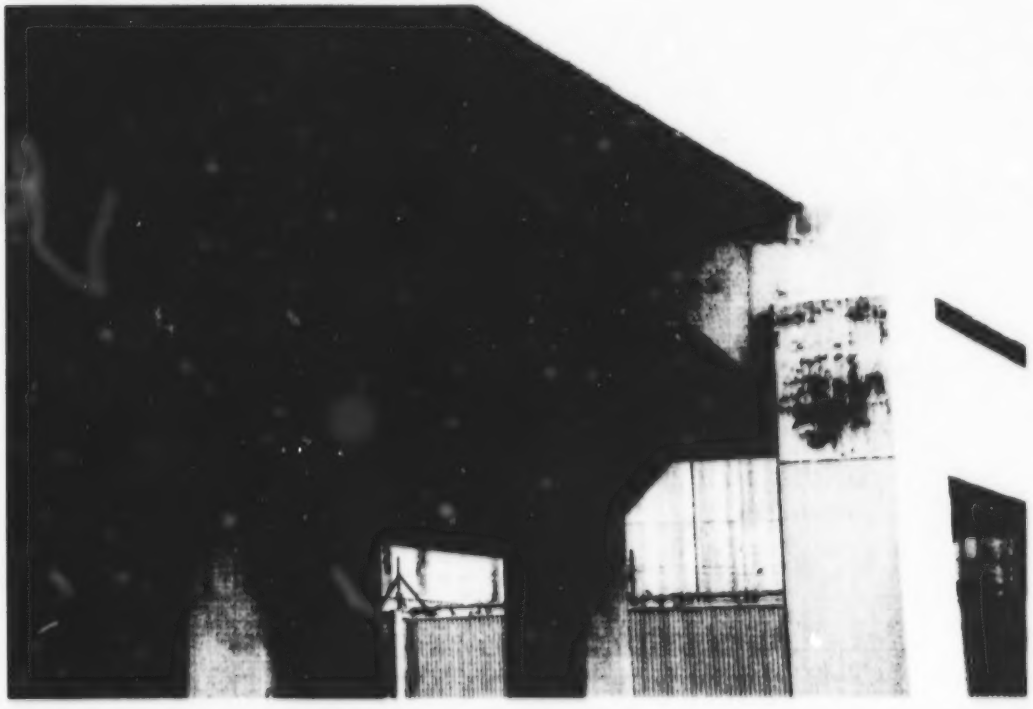

Figure 12 Area previously repaired on the west side of the support beam at Joint 20. This repair was found to be debonded.

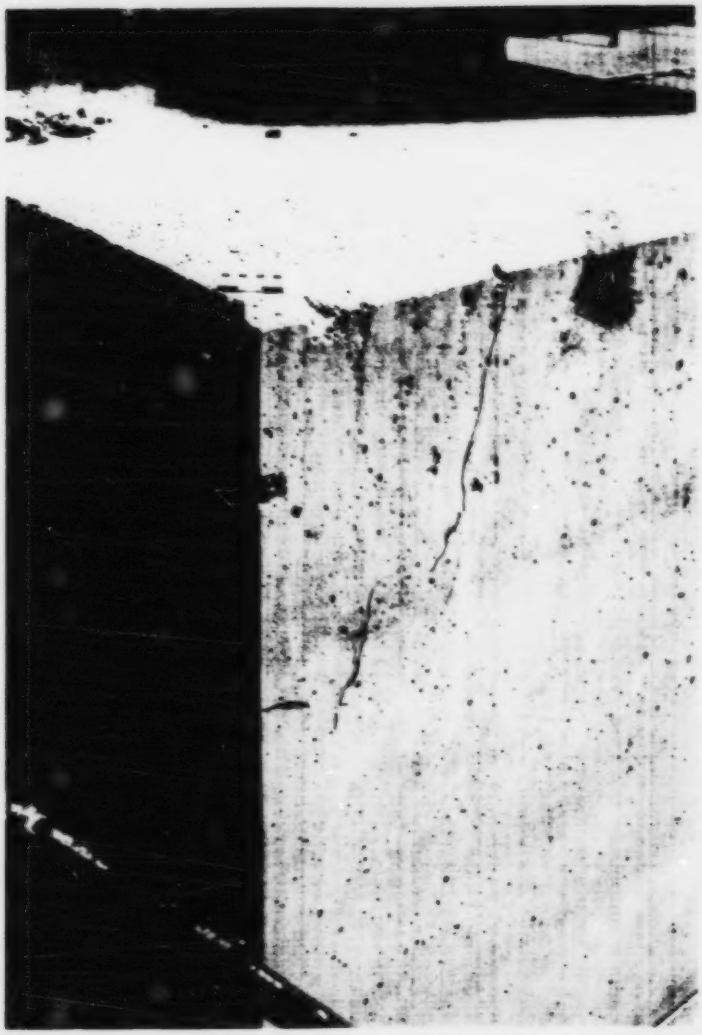

Figure 13 Cracked and spalled concrete on the southwest corner of the support for Joint 36.

APPENDIX A

PICKERING NGS 1990 OUTAGE
PRESSURE RELIEF DUCT
HALF-CELL POTENTIAL MEASUREMENTS
OF REINFORCING STEEL

31602
new P2-10

FOR ONTARIO HYDRO USE ONLY
Unless release outside is authorized
by a director

ontario hydro
research division

TO: Mr. H. Caratin
Concrete Technology Section
Civil Research Department

ESTIMATION OF THE CORROSION ACTIVITY OF THE REINFORCING STEEL IN CONCRETE DURING THE 1990 PRESSURE RELIEF DUCT OUTAGE AT PICKERING NGS A AND B

A.C. Heidon

The electrical half cell potentials of the reinforcing steel were measured at two locations in the Pressure Relief Duct floor. The potentials at Hinge Joint 12, Pickering A indicated that there was a greater than 90% probability that no reinforcing steel was corroding at the time of the measurement. One potential at Hinge Joint 50, Pickering B indicated that the corrosion activity of the reinforcing at that one location was uncertain at the time of the measurement.

INTRODUCTION

This corrosion survey was conducted at the request of Mr. H. Caratin of the Civil Research Department and will be included as an Appendix to his report on the inspection of the Pressure Relief Duct.

The measurement of the corrosion activity of the reinforcing steel was requested at two Hinge Joints in the Pressure Relief Duct floor.

The Standard Test Method for Half Cell Potentials of Reinforcing Steel in Concrete ANSI/ASTM C876-87 was used. This method may be used to assess the relative extent and progress of corrosion of steel embedded in concrete members. This method is applicable to members regardless of their size or the depth of concrete cover over the reinforcing steel. The results obtained by this method should not be considered as a means for estimating the structural properties of the steel or of the reinforced concrete member.

METHOD

The testing apparatus consisted of a copper-copper sulphate half cell, a digital voltmeter with an input impedance of 10MΩ, a supply of small sponges and electrical lead wires.

A grid with a spacing of 1.0 m (3.3 feet) was marked out on the surface of the floor where readings were to be made. The reinforcing steel was exposed by drilling in the floor slab. A direct electrical connection for the positive terminal of the digital voltmeter was made to the reinforcing steel by means

of a magnet after cleaning the steel surface with a portable drill and wire cup brush. The copper-copper sulphate half cell was connected to the negative terminal of the digital voltmeter.

The surface of the concrete at each grid point was chipped with a geological hammer to remove any dielectric coating that had formed. The grid points were sprayed with a wetting solution consisting of 95 mL of liquid household detergent thoroughly mixed with 19L of potable water. Sponges soaked in the wetting solution were placed on the grid points. The copper-copper sulphate reference electrode was pressed against the wet sponges and the readings recorded.

OBSERVATIONS

The measured half cell potentials are given in the attached Figure.

INTERPRETATION OF RESULTS

This interpretation is taken from ANSI/ASTM C876-87, "Standard Test Method for Half Cell Potentials of Reinforcing Steel in Concrete".

9.1 Laboratory testing of reinforced concrete specimens indicates the following regarding the significance of the numerical values of the potentials measured. Voltages listed are referenced to the copper-copper sulfate (CSE) half cell.

9.1.1 If potentials over an area are more positive than -0.20 V CSE, there is a greater than 90% probability that no reinforcing steel corrosion is occurring in that area at the time of measurement.

9.1.2 If potentials over an area are in the range of -0.20 to -0.35 V CSE corrosion activity of the reinforcing steel in that area is uncertain.

9.1.3 If potentials over an area are more negative than -0.35 V CSE, there is a greater than 90% probability that reinforcing steel corrosion is occurring in that area at the time of measurement.

9.1.4 In laboratory tests where potentials were more negative than -0.50 V, approximately half of the specimens cracked due to corrosion activity.

9.1.5 Positive readings, if obtained, generally indicate a poor connection with the steel, insufficient moisture in the concrete, or the presence of stray currents and should not be considered valid.

CONCLUSION

All the potentials of the reinforcing steel in the floor of the Pressure Relief Duct at Hinge Joint 12 were more positive than -0.20 volts CSE. This indicated that there was greater than 90% probability that no reinforcing steel corrosion was occurring at this location at the time of measurement.

At Hinge Joint 50 reading 2b was just at -0.20 V CSE indicating that corrosion activity of the reinforcing steel was uncertain. The section of reinforcing steel exposed for this test, which was close to 2b was, however, not corroding. This indicated that the reinforcing steel at 2b was likely not corroding.

It is recommended that the potential of the reinforcing steel at Hinge Joint 50 should be measured again at the next inspection.

This survey was conducted by Miss B.I. Guest and Mr. A.C. Headon of the Metallurgical Research Department.

Approved by:

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Supervising Scientist
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Technology Section
Metallurgical Research Dept

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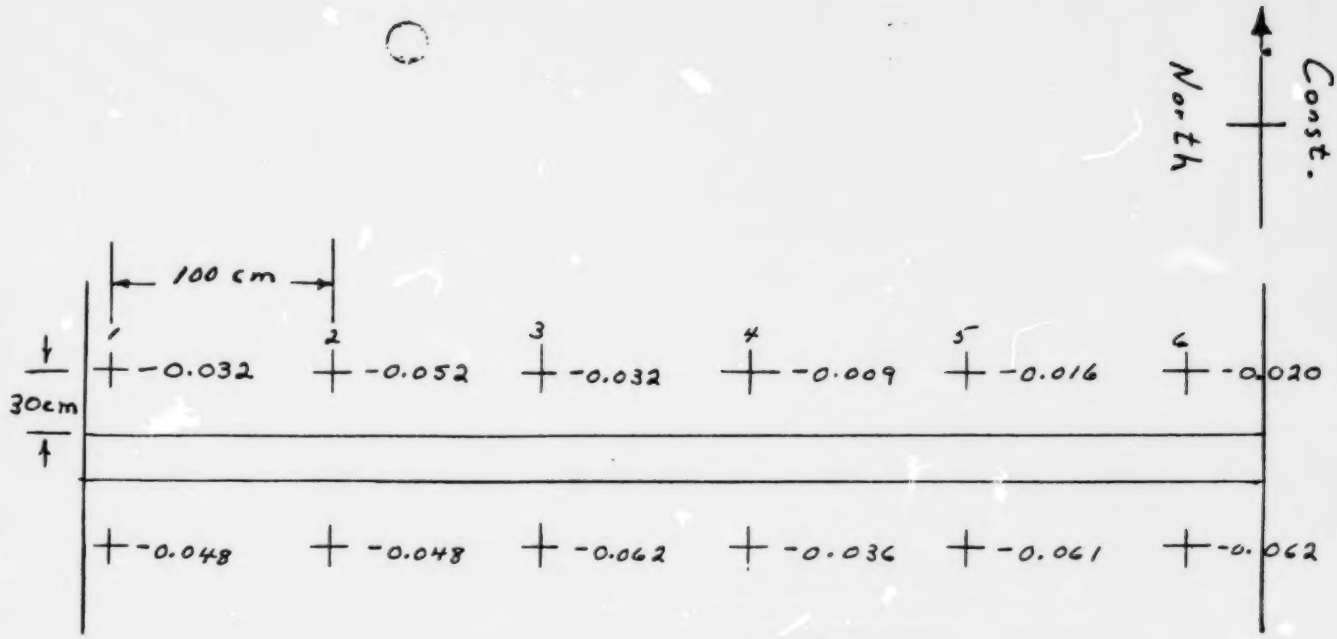
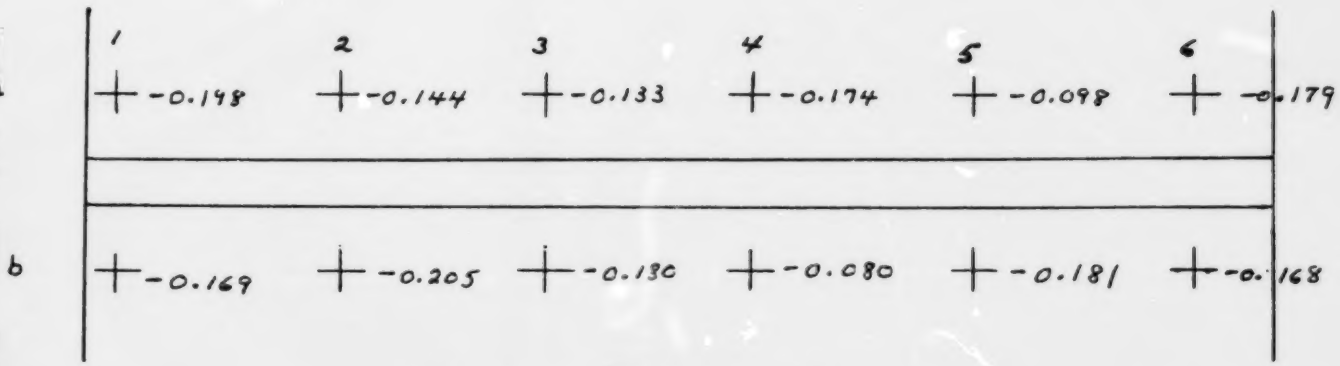


HJ 12 Pickering A



HJ 50 Pickering B

Pressure Relief Duct Hinge Joints

Readings in volts versus a $Cu/CuSO_4$ half cell. Grid spacing 1.0 m (3.3 feet)